













CONNECTED VEHICLE PILOT

Deployment Program



SESSION 3: EVALUATING PERFORMANCE AND LONG-TERM SUSTAINMENT



SESSION AGENDA



- Session Introduction
 - Kate Hartman, Chief, Research, Evaluation, & Management, ITS JPO, USDOT
- CV Pilots Evaluation Overview
 - Meenakshy Vasudevan, Senior Principal, Noblis
- Safety Evaluation Overview
 - Emily Nodine, Technical Project Manager, Volpe
- Mobility, Environment, and Public Agency Efficiency Evaluation Overview
 - Mike Lukuc, Program Manager and Research Scientist, TTI
- Financial and Institutional Evaluation Overview
 - Mike Lukuc, Program Manager and Research Scientist, TTI
- Q&A at the end of each topic

Session Introduction



Session Objectives

 To present the goals, challenges, and approaches for an *independent* evaluation of CV Pilots

Session Topics:

- USDOT's vision for an independent evaluation of CV Pilots, and challenges and possible solutions
- Safety evaluation approach, including the Safety Pilot evaluation experiences and the safety evaluation plan/concept for CV Pilots
- Mobility, environmental and public agency efficiency evaluation plans
- Institutional and sustainability evaluation goals



Meenakshy Vasudevan

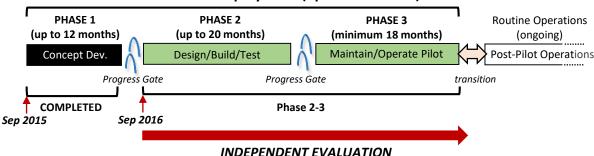
Noblis

CV Pilots Evaluation Overview

CV PILOT SCHEDULE



Connected Vehicle Pilot Deployment (up to 50 months)



- Phase 1: Concept Development (COMPLETE)
- Creates the foundational plan to enable further design and deployment
- Progress Gate: Is the concept ready for deployment?
- Phase 2: Design/Build/Test (CURRENT PHASE- began September 1, 2016)
 - Design, build, and test to ensure deployment functions as intended (both technically and institutionally)
 - Progress Gate: Does the system function as planned?
- Phase 3: Maintain/Operate
 - Operate and maintain system; Assess performance of the deployed system
- Post Pilot Operations (CV tech integrated into operational practice)



CV PILOTS EVALUATION PURPOSE



- INFORM PROSPECTIVE DEPLOYERS of CV-enabled applications of:
 - potential safety, mobility, environmental, and public agency efficiency (SMEP)
 impacts and user satisfaction of deployments
 - potential deployment costs
 - practical institutional and financial models for long-term deployment
- **INFORM USDOT** on effectiveness of the CV Pilots program in:
 - creating proven and transferable deployment concepts
 - demonstrating measureable short and long term SMEP impacts
 - overcoming deployment challenges
 - accelerating deployment of successful and sustainable CV applications

MULTI-TIERED EVALUATION



CV Pilot Site-Specific Evaluation

- Conduct cost-benefit SMEP analyses
- Assess acceptance/satisfaction of pilots
- Assess efficacy of deployed institutional/financial models
- Document lessons learned

CV Pilot National-Level Evaluation

Conduct national-level evaluation of CV Deployments

CV Pilot Program Evaluation

- Assess whether performance-management focus of pilot deployments was beneficial
- Assess if the program achieved its vision cost-effectively



Lack of Sufficient Data

- Challenge
 - Observed changes in performance may not be statistically significant due to lack of sufficient data (e.g., quantity, detail):
 - low exposure (e.g., Wrong way entry warnings may be very rare)
 - aggregated data/gaps in data/obscured data due to privacy constraints
 - small sample of crash data
- Possible Solutions
 - Collect additional data but, constrained by resources/schedule
 - Use surrogate measures to assess safety impacts
 - Supplement with simulation
 - Tailor evaluation approach



Erroneous Data

- Challenge
 - Performance measurement based on erroneous data can be misleading, and lead to lack of credibility and usefulness of estimated performance
- Possible Solution
 - Allocate resources for data quality verification
 - Establish data quality standards
 - Check for quality using a combination of automated and manual procedures



Unsubstantiated Validity of Alerts/Warnings

- Challenge
 - Objective data to support validation of application accuracy are not available since collecting detailed research data is out of scope for operational field test
- Possible Solutions
 - Verify accuracy of applications during operational readiness tests (predeployment)
 - Estimate accuracy of alerts/warnings using site-provided BSM and other supplementary data



Confounding Factors

- Challenges
 - Inability to control for confounding factors can lead to misleading conclusions
- Possible Solutions
 - Use robust experimental designs
 - Randomized Experimental Design with control/treatment groups
 - Quasi-Experimental Design (if randomization is infeasible)
 - Use statistical techniques (e.g., cluster analysis, counterfactual modeling) or supplement with modeling and simulation



Access to Site Participants

- Challenge
 - Restricted access to site participants for conducting surveys/interviews
- Possible Solution
 - Allocate resources to coordinate with sites' Institutional Review Boards (IRB)
 - Engage with sites' IRBs early in the process to approve release of necessary participant data

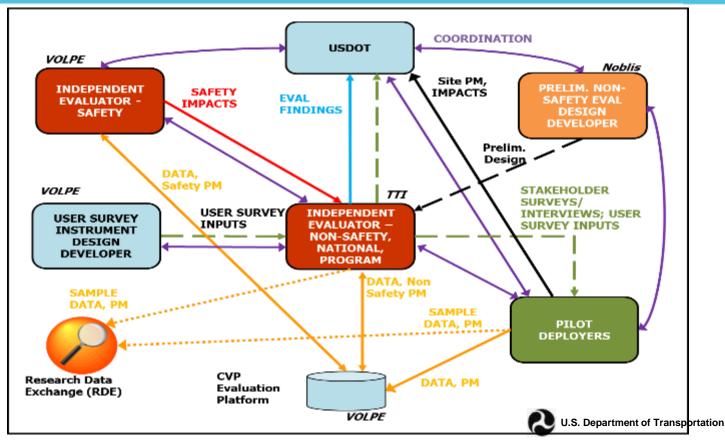


Retention of Institutional Memory

- Challenge
 - Retention of institutional memory as a result of possible staff turnover due to the long duration of the deployment; can lead to wasted resources and falling behind schedule
- Possible Solution
 - Document procedures, processes, challenges, and resolutions frequently

COMPLEX PROBLEM REQUIRES DIVERSE TALENTS (DIVIDE AND CONQUER)







Questions & Answers





Emily Nodine

Volpe

Safety Evaluation Overview

SAFETY EVALUATION OVERALL GOAL/APPROACH



Leverage site generated data to conduct the most thorough evaluation possible:

Connected Vehicle Data



Other operational data (e.g., speed sensors)



SAFETY EVALUATION GOALS

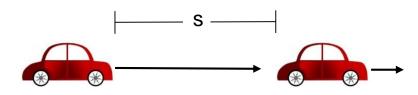


Achieve a detailed understanding of the safety impact of the CV deployments at each pilot site:

1. Annual change in relevant crash rates



Impact on surrogate safety measures



SITE SPECIFIC GOALS/APPROACH



1. Applications deployed vs. Crash types

Safety Application	Rear-End Crash	Lane-Change Crash	Crossing- Path Crash	Pedestrian- Crossing Crash
FCW	X			
LCW		X		
RLVW			X	
PED-X				X

SITE SPECIFIC GOALS/APPROACH (CONT.)



2. Application type



Vs.



3. Vehicle types











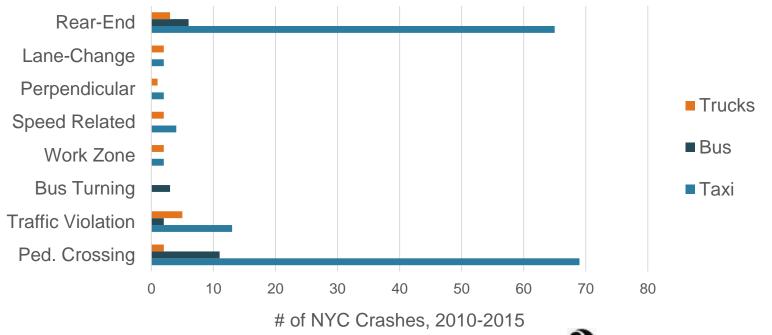


4. Data availability

SITE SPECIFIC GOALS/APPROACH (CONT.)



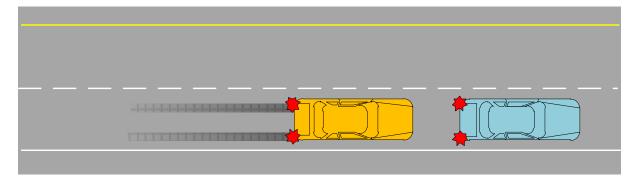
5. Target crash population



CONFLICT ANALYSES



 Conflicts: High-risk, near-crash scenarios where drivers had to intervene to avoid a crash



- □ Conflict Metrics:
 - Exposure
 - □ Response

New York City Evaluation Overview

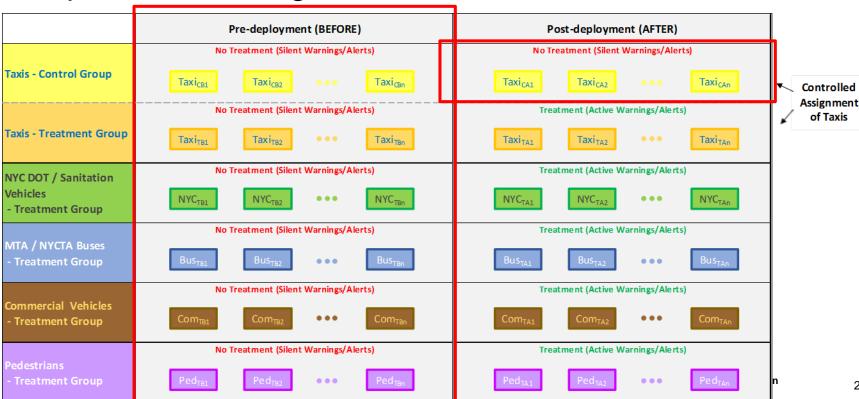




NYC EVALUATION DESIGN CONSIDERATIONS



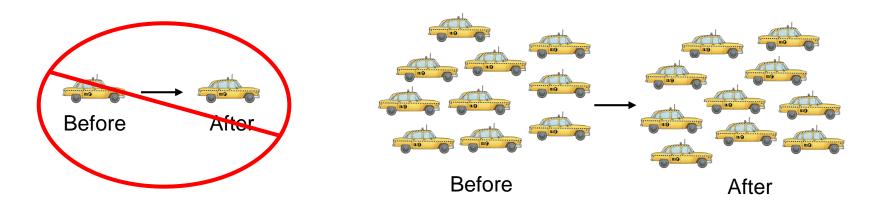
Experimental Design



NYC EVALUATION DESIGN CONSIDERATIONS



- Limited to triggered (not continuous) data collection
- No vehicle identifiers



Small sample size of target crash population

NYC OVERALL APPROACH



Step 1: Identify driving conflict events

Step 2: Compare driver response to conflicts

Step 3: Estimate crash reduction effectiveness using Monte Carlo Simulation

Step 4: Evaluate driving performance for "cautionary" safety applications (EEBL, BSW, RLVW, Speed Compliance)

TAMPA FLORIDA EVALUATION OVERVIEW

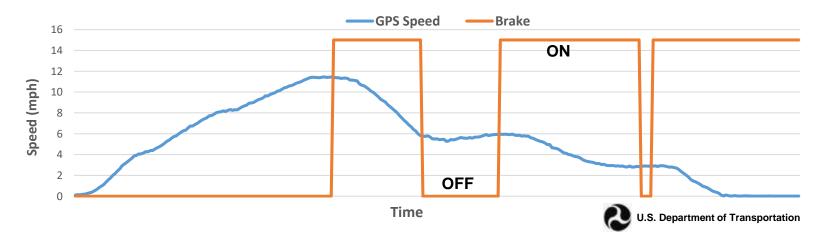




TAMPA EVALUATION DESIGN CONSIDERATIONS



- Experimental Design
 - Before/After
- CAN data (objective vehicle input data) are not being collected





TAMPA EVALUATION DESIGN CONSIDERATIONS

Potential for low exposure for certain applications

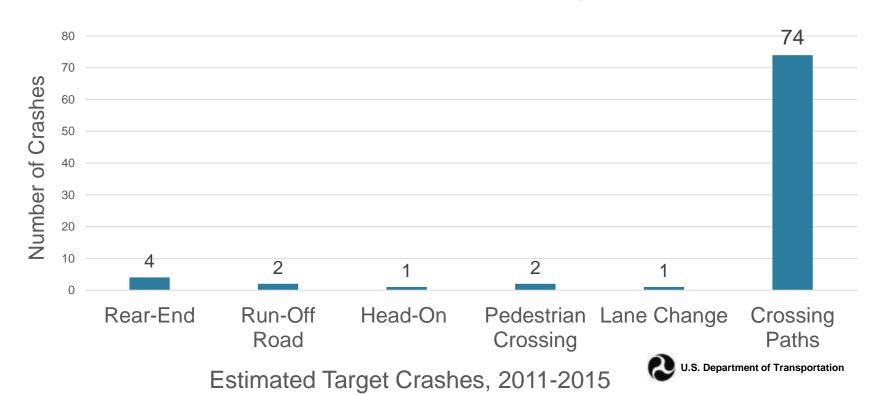
E.g., Wrong-Way Entry Warning







Extremely small sample size of target crash population



TAMPA OVERALL APPROACH



Step 1: Identify driving conflict events

Step 2: Compare change in exposure to conflicts

Step 3: Compare change in response to conflicts

Step 4: Estimate crash reduction effectiveness using Monte Carlo Simulation

Step 5: Evaluate driving performance

- e.g. Speed approaching REL, frequency of wrong way entries

WYOMING EVALUATION OVERVIEW





WYOMING EVALUATION DESIGN CONSIDERATIONS

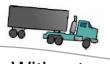


- Experimental Design
 - -Before/After
 - –With/Without (unequipped vehicles)









Without



Without



With

WYOMING EVALUATION DESIGN CONSIDERATIONS



- Most applications are cautionary (all but FCW)
 - Conflict analysis will not be conducted
- Isolating incremental improvements above existing sophisticated TMC system



VS.





WYOMING OVERALL APPROACH



- 1. Assess changes in driving speed
 - Work zones
 - Weather
- 2. Assess changes in crash rates
 - Total crash rates
 - # of vehicles in a crash
- 3. Characterize driver response to warnings

WANT TO KNOW MORE?



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Questions & Answers



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Texas A&M Transportation Institute

Mobility, Environmental and Public Agency Efficiency (MEP) Evaluation of the CV Pilot Deployments

TTI EVALUATION TEAM









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MEP EVALUATION - OVERALL OBJECTIVES



Conduct a comprehensive evaluation of each of the NYC, THEA and WY CV Pilot Deployments in order to:

- Assess the MEP impacts
- Perform a SMEP cost-benefit analysis for each site, incorporating Volpe's site-specific safety evaluation results
- Evaluate user perceptions/satisfaction of the SMEP impacts generated by the CV Pilot Deployments
- Document lessons learned



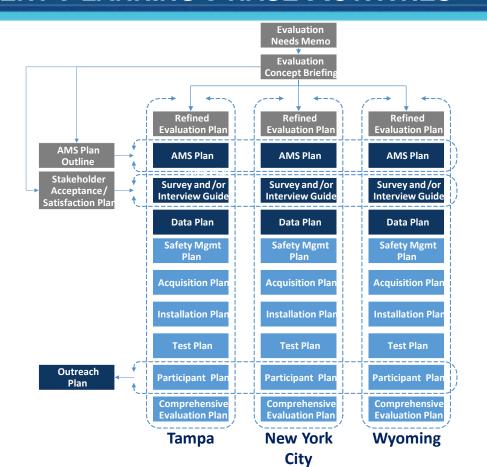


Tampa (THEA) WYDOT



MEP EVALUATION CURRENT PLANNING PHASE ACTIVITIES

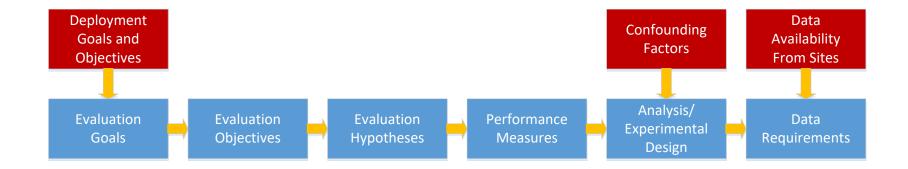






EVALUATION CONCEPT DEVELOPMENT PROCESS





USDOT AND **IE** EVALUATION GOALS



US DOT	MEP Evaluation Goals – with respect to deployment of CV technology
Improve Safety	 Assess the safety impacts of deploying CV technologies Determine the impact, or unintended consequences, of V2X safety applications on overall traffic safety and operations
Improve Mobility	 Quantify the impact of the CV technologies mobility in the deployment corridors at each deployment site Quantify the impact of the CV technologies on user travel reliability at each deployment site Quantify the impact of CV technologies on user mobility at each deployment site
Improve Environment	6. Quantify the environmental service benefits related to improvements in mobility and safety from CV technologies at each deployment site

USDOT AND IE EVALUATION GOALS (CONTINUED)



US DOT Goals	MEP Evaluation Goals – with respect to deployment of CV technology
Improve Public Agency Efficiency	7. Quantify the impact of each deployment impacted on public agency efficiencies in addressing the traveling public's needs
Positive Benefit/Cost	8. Assess the societal benefits and costs associated with each deployment
Positive Stakeholder Experience & Knowledge Transfer	 Assess the user satisfaction associated with each deployment Document the lessons learned and stakeholder acceptance of each deployment Document the impact of confounding factors on the benefits of each deployment

MEP EVALUATION – OVERALL APPROACH



- Perform Observation-based Analyses where Possible
 - Leverage data generated by the sites
 - Collect additional data if needed
- Complement with Simulation-based Analyses
 - Quantify system-wide impacts of the deployment
 - Address questions that data collected by sites cannot answer
 - Incorporate Volpe's impact analysis results to model the safety impact of deployed applications on traffic operations
 - Control confounding factors through simulation and demand modeling
- Conduct User Surveys to gather feedback on MEP impacts
- Leverage CV Pilot Performance Evaluation Platform for data storage and analytics

Department of Transportation

MOBILITY IMPACTS ANALYSIS APPROACH



- Observation-based Analysis
 - Rely on data collected from sites
 - May collect additional data to fill information gaps
- Simulation-based Analysis
 - Calibrated with field data for CVs and Non-CVs
 - Monitor vehicle throughput changes for various simulation scenarios to estimate impacts of different CV market penetration
 - Models will provide estimates of performance measures
 - Travel time reliability will be estimated by weighting scenario outputs by probability

SAFETY IMPACTS ANALYSIS APPROACH



- Use simulation modeling to test impacts of different crash scenarios on traffic operations and weight the results according to changes in frequency.
- Rely on Volpe safety impacts assessment particularly estimates in reduction in crashes
- Utilize a year of crash data in cluster analysis to identify modeling scenarios.
- Critical for monitoring economic benefits of technologies

ENVIRONMENTAL IMPACTS ANALYSIS APPROACH



- Emissions and Fuel Consumption Modeling
 - Will integrate MOVES emissions model with traffic simulation model using a probevehicle approach (second-by-second vehicle trajectories)
 - Compare with and without CV technologies
 - Assess changes in mobility, which affect fuel consumption and emissions
- Eco-Services Data Analysis
 - Wildlife to vehicle collisions
 - Wyoming only
 - Data sources
 - Reported collisions in which police or tow truck operators are involved,
 - Database of carcasses cleaned up by Wyoming DOT

PUBLIC AGENCY EFFICIENCY ANALYSIS APPROACH



- Observation-based analysis
 - Analyze agencies operations logs
- Simulation-based analysis
 - Estimate transit ridership impacts using travel time ridership elasticities
 - Unable to predict incident detection times, driver perceptions, agency perceptions, and benefit cost ratios
- Administer stakeholder surveys/interviews
 - Gather feedback on improvements or changes to decision making, etc.
- Assess changes in detection, notification, and responses to traffic events and situations occurring on the network.

USER SATISFACTION ANALYSIS APPROACH



- Develop baseline and post-deployment survey instruments with Volpe
- Coordinate with site teams to administer baseline and post-deployment surveys
- Analyze survey data to:
 - Understand and describe user samples.
 - Perform subgroup analysis e.g., to be able to compare CV attitudes and experiences across key subgroups
 - Assess the impacts of CV systems

<u>Site-specific differences</u> in user groups:

- New York: Taxi, UPS operators, Sanitation Truck drivers, and Bus drivers
- Tampa: Bus and Streetcar Drivers and Pedestrians
- Wyoming: Snowplow drivers, Highway Patrol, Commercial Truck drivers

STAKEHOLDER ACCEPTANCE ANALYSIS APPROACH



Qualitative interviews

- <u>Pre-deployment</u> to elicit vision, goals, expectations immediately subsequent to the planning/design stage
- <u>Near-term post-deployment</u> to gather information about deployment experiences, outcomes, and satisfaction shortly after activation
- Long-term post-deployment to capture information about deployment experiences, outcomes, and satisfaction towards the end of the deployment

Online survey

 <u>Post-deploymen</u>t to gather feedback on how well the pilots fulfilled the goals and objectives of entities less involved in day-to-day pilot planning and execution.

Workshop

Post-deployment (after post-deployment interviews) to foster cross-stakeholder dialogue about challenges, solutions, lesions learned as well as clarify and confirm key findings

DATA COLLECTION BY STAKEHOLDER

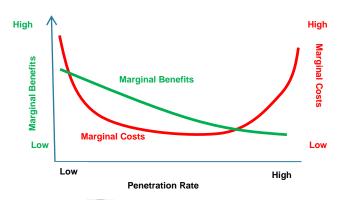


Stakeholder Type	Pre-Deployment Interviews	Post-Deployment Interviews		Survey	Workshop
		Near-Term	Long-Term		
Deployment Managers	х	х	х		х
Deployment Team	х	х			х
Operating Agencies	х		х		х
Fleet Operators				х	
Supporting Agencies				х	
Policy Makers	Х		х		

BENEFIT/COSTS ANALYSIS - APPROACH



- Spans the <u>timeframe</u> from planning to 10 years post deployment
- Estimates the <u>benefits and costs</u> for both the actual and higher CV penetration rates
- Considers *costs*, such as:
 - To plan, implement, operate and maintain the CV deployment projects.
 - Marginal costs incurred by agencies (or users) due to the project
- Monetizes benefits related to:
 - Mobility
 - Safety
 - Emissions
 - Fuel consumption
 - Vehicle operations



MEP EVALUATION CHALLENGES



- Data availability and obfuscation
 - Deployment vs. research project
 - Low market penetration rate in deployment zones
- Mobility benefit dependency upon safety benefits
 - NYC and Tampa deployments are predominantly safety related
 - Mobility benefits assessed through modeling
- Impact of confounding factors
 - Weather
 - Variations in demand
 - Work zones and maintenance
 - Special Events and manual intersection control
 - Traffic accidents and emergency response
- WY evaluation has unique challenges
 - Weather and Incident response



QUESTIONS





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Mike Lukuc

Texas A&M Transportation Institute

User and Stakeholder Acceptance/Satisfaction, Financial and Institutional Assessment of CV Pilot Deployment

TTI EVALUATION TEAM









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FINANCIAL AND INSTITUTIONAL EVALUATION - OBJECTIVES



For each of the NYC, Tampa and WY CV Pilot Deployments:

- Assess <u>user and stakeholder acceptance/satisfaction</u> associated with the financial and institutional elements of each CV Pilot deployment site
- Assess the <u>change in the financial and institutional</u> setting, frameworks, models, and elements, as well as the associated impacts
- Evaluate the likelihood of achieving <u>financial sustainability</u>



FINANCIAL AND INSTITUTIONAL EVALUATION - PRIMARY ACTIVITIES



For each of the three CV Pilot Deployments:

- Develop a financial evaluation plan
- Develop an institutional evaluation plan
- Develop/refine user acceptance and stakeholder evaluation survey instruments
- Develop/refine a stakeholder acceptance/satisfaction evaluation plan and survey instrument guides
- Assess user and stakeholder acceptance/satisfaction, and financial and institutional impacts

DEVELOP FINANCIAL EVALUATION PLANGOALS



- Assess the changes in the financial settings, frameworks, models, elements and associated impacts from the planned and implemented CV deployments
 - Relative to the baseline
 - Three time periods
 - Short-term → 1 to 2 years
 - Mid-term → 3 to 5 years
 - Long-Term → 7 to 10 years



DEVELOP FINANCIAL EVALUATION PLAN – GOALS (CONT.)



- Develop discounted cash flow (DCF) model to assess financial sustainability
 - Comprehensive checklist of potential financial factors
 - Determine data needs
 - Collect baseline data
 - Conduct assessment of financial risks
 - Develop methodology for conducting periodic updates
- Survey users/stakeholders
 - Willingness to pay
 - Price break points
 - Potential subscription options
- Conduct periodic assessments



(Source: The bull com au)

DEVELOP INSTITUTIONAL EVALUATION PLAN — GOALS



- Develop an Institutional Evaluation Plan to assess the effects of changes in institutions at each site due to CV deployments
- Leverage USDOT Guidance for Connected Vehicle Deployments to identify and evaluate institutional integration issues
- Supplement with local experience and knowledge
- Develop a risk assessment matrix
- Issues to be examined include:
 - Governance
 - Public/Private Partnerships
 - Organizational structure
 - Legislation
 - Use of industrial organization



DEVELOP INSTITUTIONAL EVALUATION PLAN – APPROACH



- Identify potential institutional factors to be examined
- Map institutional factors to sites
- Determine baseline conditions
- Develop methodology for assessing/estimating impacts
- Identify information and data needs to be collected at each site
- Integrate in the Stakeholder Acceptance Interviews/Survey assessment



DEVELOP USER ACCEPTANCE/ SATISFACTION SURVEY INSTRUMENTS - GOALS



- Develop/refine site-specific user acceptance/satisfaction survey instruments
 - Assess user perceptions and satisfaction with the changes in the financial and institutional settings, frameworks, models, and elements
- Refine both baseline and post-deployment user survey instruments to ensure that alignment with these evaluation plans



DEVELOP STAKEHOLDER ACCEPTANCE EVALUATION PLAN AND SURVEY/INTERVIEW GUIDES



- Stakeholder Acceptance Evaluation Plan and Survey/Interview Guides currently under development
- Purpose of this activity is to integrate data needs for financial and institutional plans into stakeholder acceptance data collection



STAKEHOLDER ASSESSMENT TOOLS



Stakeholder Type	Pre- Deployment			Survey	Workshop
	Interviews	Near-Term	Long-Term		
Deployment Managers	Х	Х	Х		Х
Deployment Team	Х	X			X
Operating Agencies	Х		X		X
Fleet Operators				X	
Supporting Agencies				X	
Policymakers	X		X		

ASSESS USER AND STAKEHOLDER ACCEPTANCE/SATISFACTION AND FINANCIAL AND INSTITUTIONAL IMPACTS



Goals:

- Execute the financial and institutional evaluation plans
- Analyze user acceptance/satisfaction survey responses provided by the deployment sites
- Administer the stakeholder surveys/interviews and analyze responses

Outcome:

Financial and Institutional Assessments



USER AND STAKEHOLDER ASSESSMENT



Purpose:

- Analyze results of User Satisfaction Survey data collected by sites
- Collect and analyze Stakeholder Acceptance Data
- User Satisfaction Survey
 - Extract data from CV Performance Evaluation Platform
 - Aggregate and analyze survey responses
 - Execution of surveys responsibility of sites
- Stakeholder Acceptance
 - Execute Stakeholder Acceptance Evaluation Plan
 - Interviews/On-line Survey/Workshop
 - Documents results



FINANCIAL AND INSTITUTIONAL ASSESSMENT



Purpose:

- Assess extent financial and institutional arrangement can sustain deployment
- Capture and document:
 - Financial and institutional challenges and solutions
 - Financial and institutional lessons learned



FINANCIAL AND INSTITUTIONAL ASSESSMENT



Semi-annual site assessments

- Assess progress achieving sustainability and performance goals
- Identify and analyze any financial and institutional challenges and solution encountered
- Gauge the likelihood of achieving financial sustainability
- Conduct preliminary analysis of user survey responses
- Conduct preliminary analysis of stakeholder survey responses







QUESTIONS/COMMENTS



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STAY CONNECTED



Visit USDOT Exhibition Booth

USDOT Booth #1301

Talk to the Pilot Site Representatives

October 31, 2017

WYDOT : 2:00 PM - 3:00 PM

Tampa (THEA): 3:00 PM - 4:00 PM

NYCDOT : 4:00 PM - 5:00 PM

November 1, 2017

NYCDOT : 9:00 AM - 10:00 AM

Tampa (THEA): 10:00 AM - 11:00 AM

WYDOT : 11:00 AM - 12:00 PM







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Visit CV Pilot and Pilot Site Websites for more Information:

CV Pilots Program: http://www.its.dot.gov/pilots

NYCDOT Pilot: https://www.cvp.nyc/

Tampa (THEA): https://www.tampacvpilot.com/

Wyoming DOT: https://wydotcvp.wyoroad.info/

